NORTH ATLANTIC TREATY ORGANIZATION
ORGANISATION DU TRAITE DE L'ATLANTIQUE NORD

MILITARY AGENCY FOR STANDARDIZATION (MAS)
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14 July 1998 MAS/285-PPS/4443

STANAG 4443 PPS (EDITION 1) - EXPLOSIVES UNIAXIAL COMPRESSIVE TEST

Reference:
AC/310-D/130 dated 21 March 1995 (Edition 1)(1st Draft)

1. The enclosed NATO Standardization Agreement which has been ratified by nations as reflected in page iii is promulgated herewith.

2. The reference listed above is to be destroyed in accordance with local document destruction procedures.

3. AAP-4 should be amended to reflect the latest status of the STANAG (and AP if applicable).

ACTION BY NATIONAL STAFFS

4. National staffs are requested to examine page iii of the STANAG and, if they have not already done so, advise the Defence Support Division, IS, through their national delegation as appropriate of their intention regarding its ratification and implementation.

A. GRØNHEIM
Major General, NOAF
Chairman MAS

Enclosure:
STANAG 4443 (Edition 1)

STANAG No. 4443
(Edition 1)

NORTH ATLANTIC TREATY ORGANIZATION
(NATO)

MILITARY AGENCY FOR STANDARDIZATION
(MAS)

STANDARDIZATION AGREEMENT
(STANAG)

SUBJECT: EXPLOSIVES UNIAXIAL COMPRESSIVE TEST

Promulgated on 14 July 1998

A. GRØNHEIM
Major General, NOAF
Chairman, MAS

RECORD OF AMENDMENTS

No.	Reference/date of amendment	Date entered	Signature

EXPLANATORY NOTES

AGREEMENT

1. This NATO Standardization Agreement (STANAG) is promulgated by the Chairman MAS under the authority vested in him by the NATO Military Committee.

2. No departure may be made from the agreement without consultation with the tasking authority. Nations may propose changes at any time to the tasking authority where they will be processed in the same manner as the original agreement.

3. Ratifying nations have agreed that national orders, manuals and instructions implementing this STANAG will include a reference to the STANAG number for purposes of identification.

DEFINITIONS

4. Ratification is "In NATO Standardization, *the fulfilment by which a member nation* formally accepts, with or without reservation, the content of a Standardization Agreement" (AAP-6).

5. Implementation is "In NATO Standardization, the fulfilment by a member nation of its obligations as specified in a Standardization Agreement" (AAP-6).

6. Reservation is "In NATO Standardization, the stated qualification by a member nation that describes the part of a Standardization Agreement that it will not implement or will implement only with limitations" (AAP-6).

RATIFICATION, IMPLEMENTATION AND RESERVATIONS

7. Page iii gives the details of ratification and implementation of this agreement. If no details are shown it signifies that the nation has not yet notified the tasking authority of its intentions. Page iv (and subsequent) gives details of reservations and proprietary rights that have been stated.

FEEDBACK

8. Any comments concerning this publication should be directed to NATO/MAS - Bvd Leopold III - 1110 Brussels - BE

STANAG 4443
(Edition 1)

NAVY/ARMY/AIR

NATO STANDARDIZATION AGREEMENT (STANAG)

EXPLOSIVES UNIAXIAL COMPRESSIVE TEST

Annexes:

A - Test procedures
B - Test Report Sheet

Related documents: none

AIM

1. The aim of this agreement is to standardize the uniaxial compressive test for explosive materials.

2. The test described in Annex A and the test report sheet described in Annex B were developed to give every country the means to determine compressive mechanical properties of explosive materials, and to know how the results were obtained.

AGREEMENT

3. Participating nations agree to use the test procedures described in Annex A and the test report sheet described in Annex B for assessing the mechanical behaviours when requested by the procuring nation.

IMPLEMENTATION OF THE AGREEMENT

4. This STANAG is implemented when a nation has issued the necessary instructions putting the contents of this agreement into effect.

TEST PROCEDURES

1. SCOPE

1.1 This method covers the determination of the mechanical properties of explosive materials loaded in compression at all strain or loading rates. Test specimens of standard shape are recommended, but because of the nature of explosive material formulation and production, non-standard specimen testing is also included.

1.2 These tests provide information on the compressive mechanical properties of explosive materials at strain rates ranging from low to high rate. Since performance and safety are influenced by the mechanical response of the materials under operational conditions, measurements should be made under conditions as close to operational as possible.

1.3. These tests provide information on the mechanical response of explosive material samples as a function of temperature, strain rate, pressure, and any other parameter deemed necessary. This information can be used to establish mechanical properties, to determine mechanical response transitions, and for quality control. These tests are commonly conducted on gun propellants.

1.4. The standard units for measurement are SI units. Temperature may be expressed in degrees Celsius where appropriate.

2. DEFINITIONS

The following definitions are given for measuring and reporting specimen response. Illustrations in Figure 1 and 2 are provided as reference for these definitions.

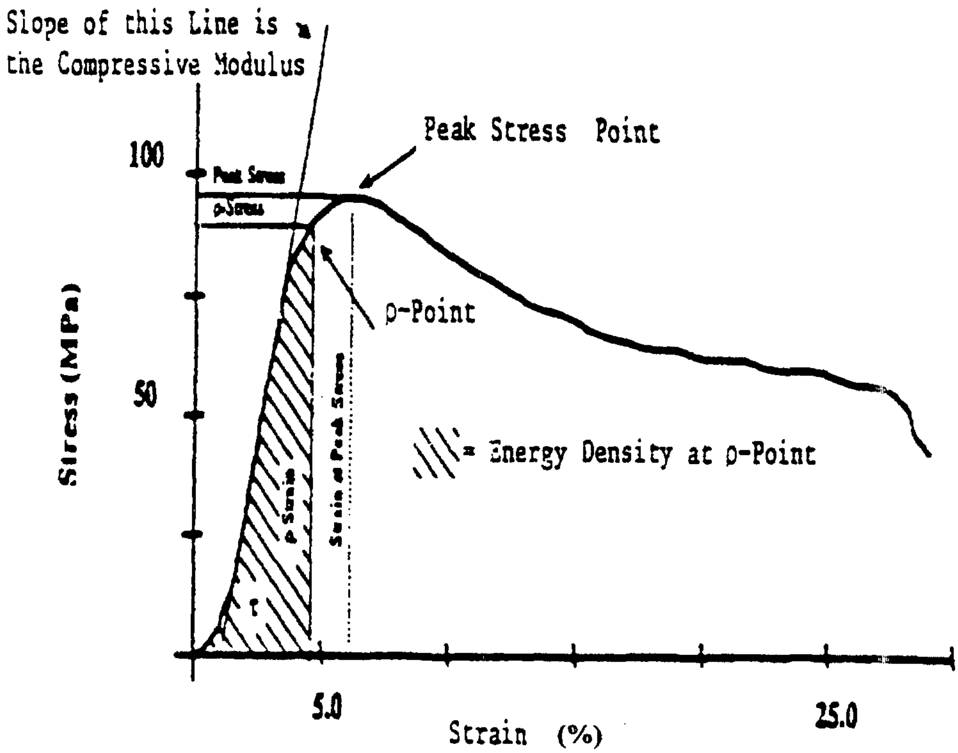


Figure 1 : Compressive Stress-Strain Diagram Showing the Location of Various Parameters

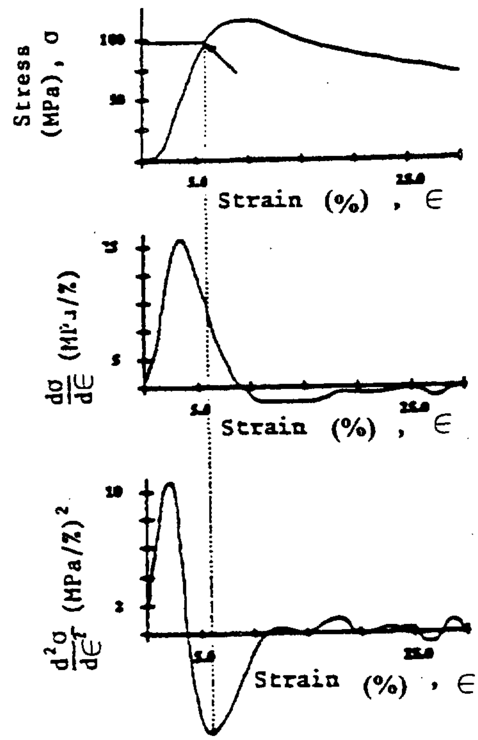


Figure 2 : Illustration of the Method Used to Determine the ρ-Point

2.1 Compressive Stress (nominal) :

The compressive load per unit net area of the original cross section carried by the specimen at any time. Stress is expressed as force per unit area.

2.2 Compressive Deformation :

The decrease in specimen length along the longitudinal axis produced by the compressive load. It is expressed as units of length.

2.3. Compressive Strain :

The ratio of the compressive deformation to the specimen length, i.e., the change in specimen length per original specimen length along the longitudinal axis. Strain is dimensionless and is commonly expressed as a percentage.

2.4. Energy Density :

The integral of the compressive stress with respect to the compressive strain. The energy density has units of energy per unit volume.

2.5. Compressive Stress-Strain Diagram :

A diagram which has the compressive values of stress on the ordinate axis plotted against the corresponding strain values on the abscissa. The locus of points is called the compressive stress-strain curve.

2.6 Compressive Proportional limit :

The point on the compressive stress-strain curve at which deviation from the initial linear stress-strain relationship is apparent.

2.7 Compressive ρ-Point:(*)

The point beyond the proportional limit where the second derivative of the stress with respect to the strain ($\frac{d^2\sigma}{d\varepsilon^2}$) is minimum. The Compressive ρ-Stress and Compressiveρ-Strain are the corresponding stress and strain at this point. (This point is not the point of minimum curvature).

2.8 Peak Stress Point :

The first point on the stress-strain curve where the first maximum stress is observed at increasing strain. The Peak Stress and the Strain at Peak Stress are the corresponding stress and strain values at this point.

2.9 Strain Rate :

The slope in the linear region of the compressive strain plotted against time before failure. The strain rate is expressed in units of inverse time.

(*) A graphical approximation to determine the ρ-point can be made by using the intersection point of the lines determined by compressive modulus and the slope of the curve after maximum load (the failure slope), as illustrated in figure 5.

2.10 Compressive Modulus of Elasticity :

The maximum slope of the compressive stress-strain curve before the peak stress. The Modulus has units of force per unit area.

2.11 Machine Compliance :

The difference between the total displacement measured and the actual specimen displacement per unit load that results from the application of load to the test specimen. If the machine distortion is a linear function of load, machine compliance should be expressed as displacement per unit force. If the machine compliance is not constant, a more complex representation must be given. The inverse of machine compliance is machine stiffness.

3. TEST APPARATUS

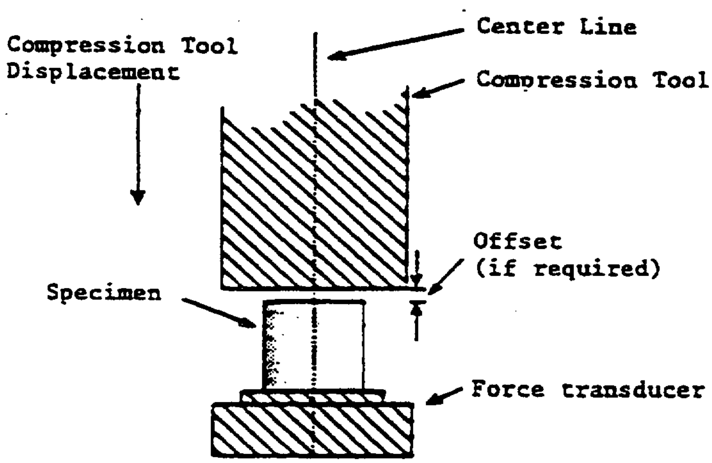


Figure 3 : Typical Coaxial Test arrangement

3.1 Testing Machine :

Any compressive testing machine may be used that is able to record simultaneous force and displacement information at uniform displacement rates. At ram speeds of less than 10 m/s the deviation of the velocity shall not exceed 25 % of the average velocity over the event of interest. Testing machines may include servo-hydraulic, screw driven, drop weight impact or other testers. A generic example of a specimen arrangement is given in Figure 3.

3.2 Displacement Measurement:

The specimen deformation should be measured by a system with a response time small enough to ensure simultaneous displacement-load recordings. Displacement measurements should be corrected for machine compliance so that only specimen deformation is reported. Measurements should indicate displacement within ±1 percent of maximum.

3.3 Load Measurement:

The load measurement must reflect the total compressive load carried by the specimen. Measurements should indicate load within ±1 percent of maximum. At least ten stress vs strain points must be recorded for each percent strain with a minimum of 20 points recorded per event.

3.4 Compression Tool :

The compression tool must be axisymmetrically aligned and the load forces must be parallel to the axis of the specimen, as indicated in figure 3.

3.5 Calibration:

Each component of the testing device should be calibrated according to the manufacturer's recommended schedule. The entire system should be verified with a well characterized material under conditions as close as possible to test conditions, to ensure that measurements are as accurate and consistent as possible. Factors to consider : Dynamic loading of the gages may cause significant error at high rates. These loads are not considered here except as noted below.

4. TEST SPECIMENS

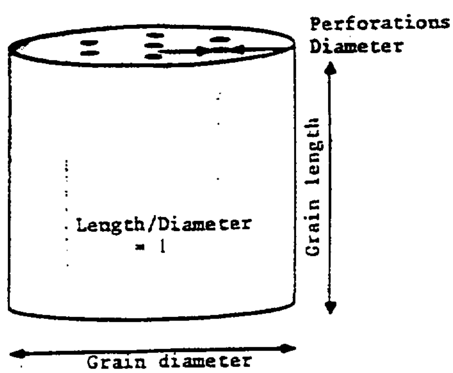


Figure 4 : Typical Gun Propellant Specimen after Preparation

4.1 For data exchange, the recommended length to diameter ratio shall be 1.00 ± 0.05, and the interior of the specimen shall be uniform solid (preferred), or contain symmetric perforations or slots parallel to the cylinder axis. The specimen ends will be flat and parallel to 0.0225 mm and perpendicular to the longitudinal axis to within 0.5°. For generic classes of explosives where a length to diameter ratio of one or where the prescribed tolerances are inappropriate, the values must be reported.

4.2 The specimen ends shall be prepared so that no fracture damage is induced. All particles that result from the end preparation shall be carefully removed from the specimen before testing in a manner that does not result in specimen damage.

4.3 Perforation diameter shall be measured on each perforation of a specimen after end preparation. Measurements should be taken on enough specimens to ensure that a representative measurement is made. Specimens on which perforation measurements are made by contact devices should not be used for testing. A typical specimen illustration is given in figure 4.

4.4 Specimen storage shall be in sealed containers until testing or preconditioning procedures begin. The temperature and relative humidity during preconditioning shall be reported.

4.5 Testing shall be done with no lubricant added to the end surfaces. If any contamination or additive is present during testing, a statement on the surface conditions must be included in the report.

5. TEST METHOD

5.1 Measurement of Test Specimen Dimensions

Each dimension shall be measured at least three times using an instrument or technique that permits accuracy and precision to within 1% of the measured dimension. Each specimen length and diameter shall be measured prior to conditioning or testing. The perforation diameter of the specimens shall have been determined as outlined above, and may be assumed to be accurate for the test specimen.

5.2 Specimen Conditioning

(a) For those tests where temperature conditioning is required, each specimen shall be conditioned within one Celsius degree of the planned test temperature for at least one hour before testing. Room temperature is 23 ± 2°C.

(b) For samples requiring temperature conditioning, the conditioned specimen shall be placed into a temperature controlled region of the test apparatus. After the specimen has been transferred, the test temperature shall be maintained (± 1°C) within the testing region for a period long enough to ensure that any disruption of the conditioning of the specimen has been corrected. Specimen conditioning information shall be recorded.

(c) If specimens are tested at other than ambient pressures, the pressure history of the specimen must be recorded for each tested sample.

5.3 Test Procedure

(a) Care will be taken to assure uniform straining. The loading shall be applied coaxially through the center of the specimen. At least five specimens shall be tested under each testing condition. If large deviations from average values result, additional tests should be performed in order to determine the nature of the scatter.

(b) Simultaneous force and displacement data, stress and strain calculations, specimen dimensions, test conditions, gage calibrations, and a photograph of a typical damaged specimen should be recorded and kept as a permanent data file. All information required to complete the NATO Data Exchange Format should also be recorded. The complete specimen lot number, as found on the material description sheet, should be kept as the primary identifier of the specimen tested. Any test identification system should be directly linked to the lot number.

(c) The test shall be conducted until the specimen fractures or until three times the ϱ-strain is reached.

6. DATA REDUCTION

6.1 Calculations

Stress shall be determined by Definition 2.1, where net area is the total cross sectional area less any perforation or other area not supporting the applied load. Strain values are determined by Definition 2.3. Machine compliance corrections to displacement shall be included in any calculations except when reporting "raw" data. All other calculations will be in accordance with the definitions listed in Section 2 or be explained in the report containing the test results.

6.2 Report

The report of test results shall be given on the NATO AOP-7 Data Exchange Format, "Uniaxial Tensile/Compressive Test" (see Attachment), and shall include at least the following : complete identification of the sample, including the source, formulation (if possible), identification numbers, and history; a statement of how the specimens were prepared, and the testing conditions used; a reference to, or description of the tester used; the total number of specimens tested per test condition; compressive stress and strain characterization parameters (illustrated), compressive modulus of elasticity, strain rate, and the mean and standard deviation (n-1) for each of these measurements; a failure characterization, and a representative compressive stress-strain diagram. A representative illustration of a tested specimen is also recommended.

7. Method for Determining an Approximate ρ-Point

7.1 The following method for approximating the ρ-point is provided for situations where it is impossible or impractical to compute the second derivative of the stress with respect to the strain. This approximation determines the ρ-point as the intersection of two lines. The first line is the line used to determine the compressive modulus. The second line is determined by the best straight line that passes through the linear section of the points in the stress-strain curve between the strain at peak strain, ϵ_m and twice, ϵ_m .

7.2 These two lines and the approximate ρ-point are indicated in the diagram below. The ρ-point determined from the second derivative is also indicated.

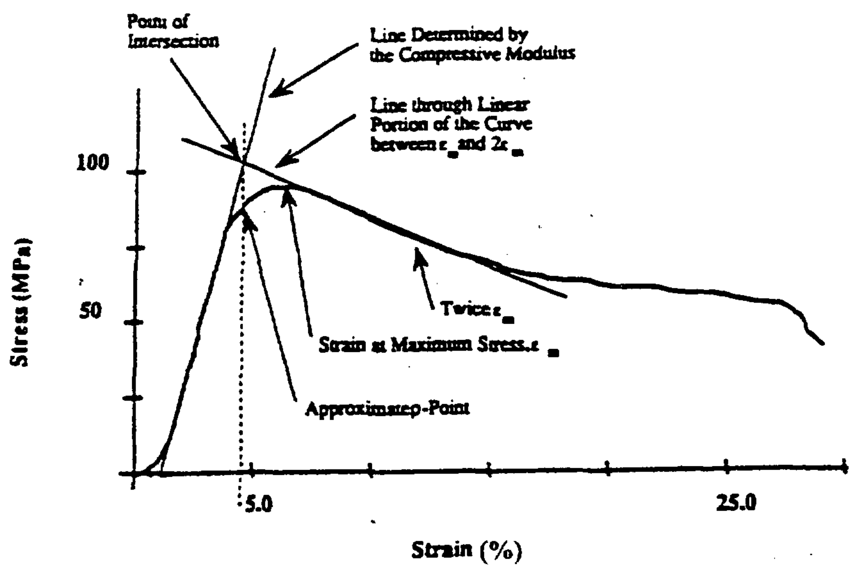


Figure 5: Compressive Stress Strain Diagram Illustrating a Method of Determining an Approximate ρ-Point

Report Reference Number:	TEST REPORT SHEET Uniaxial Compressive Test	Page ____ of ____ Page(s)

TEST SITE INFORMATION	TEST CONDITIONS
Laboratory: Date: Test Procedure: NATO Test Procedure Number: 102.01. Date Tested: POC:	Temperature (°C): Relative Humidity (%): X-Head Speed (mm/sec): Machine Type: Grip Type: Machine Stiffness (kN/mm):

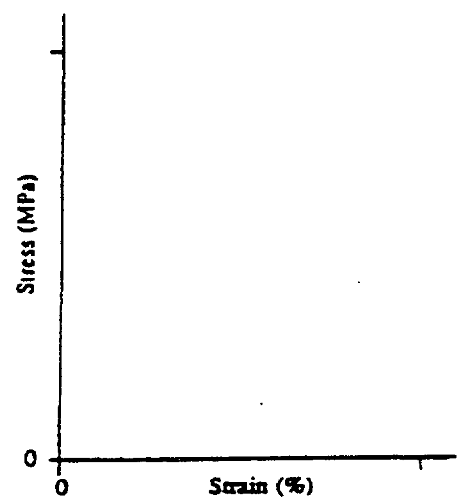
SPECIMEN INFORMATION

Dimensions: (mm)
- Length (Gage Length):
- Width:
- Thickness (Diameter):
- X-Sectional Area (mm^2):

Form:
Preparation Method:
Manufacturing Method:
Source:
Lot or ID Number:
Preconditioning:
Conditioning Period:
Composition:

Component	Percent

TYPICAL RESULTS



Test ID	Specimen T (°C)	Specimen S (mm^2)	Comments	$\dot{\varepsilon}$ (s^{-1})	σ_m (MPa)	ε_m (%)	$\sigma_{c,\varepsilon=r}$ (MPa)	$\varepsilon_{c,\varepsilon=r}$ (%)	E_0 (MPa) (GPa)
Data Sent To:			Average						
			S Dev.						

DEF (Uniaxial) Revision Date: 26 Apr 91

Report Reference
Number: *(Unique Reference Number)*

TEST REPORT SHEET
Uniaxial Compressive Test
(Instruction Sheet)

Page ____ of ____ Page(s)

TEST SITE INFORMATION

Laboratory: *(Name of Laboratory)*
Date: *(Date That Form Was Completed)*
Test Procedure: *(Name of Test Procedure Used)*
NATO Test Procedure Number: 102.01. *(Test Procedure Number)*
Date Tested: *(Date of Test)*
POC: *(Point of Contact)*

TEST CONDITIONS

Temperature (°C): *(Nominal Specimen Temperature)*
Relative Humidity (%): *(Nominal Specimen Relative Humidity)*
X-Head Speed (mm/sec): *(Cross Head Speed during Test)*
Machine Type: *(Name and Model Number of Machine)*
Grip Type: *(Name and Model Number of Grip)*
Machine Stiffness (kN/mm): *(Linear Machine Stiffness)*

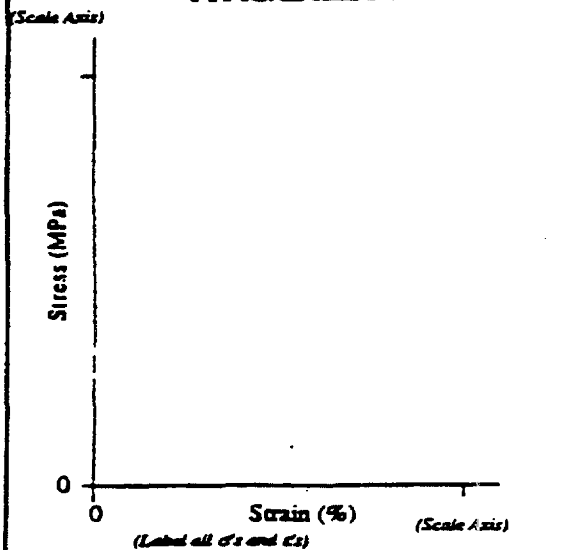
SPECIMEN INFORMATION

Dimensions: (mm)
Length (Gage Length): *(Mean Specimen Length, Width, & Thickness (Diameter))*
Width:
Thickness (Diameter):
X-Sectional Area (mm²): *(Net Cross Sectional Area)*
Form: *(Specimen Geometry Descriptor)*
Preparation Method: *(Specimen Preparation Procedure)*
Manufacturing Method: *(Specimen Processing Technique)*
Source: *(Name of Manufacturer)*
Lot or ID Number: *(Same As on Propellant Description Sheet)**
Preconditioning: *(Specimen Conditioning Descriptor)*
Conditioning Period: *(Period Specimen Was Conditioned)*
Composition: *(Specimen Name)*

Component	Percent
______	______
______	______
______	______
______	______
______	______
______	______

(Add Sheets as Needed)

TYPICAL RESULTS



Test ID	Specimen T (°C)	Specimen S (mm²)	Comments	$\dot{\varepsilon}$ (s⁻¹)	σ_m (MPa)	ε_m (%)	$\sigma_{c,g}$ or ((MPa)	$\varepsilon_{c,g}$ or ((%)	E_o (MPa) (GPa)
(Specimen Test ID Number(s))	*(Specimen Temperature)*	*(Specimen Net Cross Sectional Area)*	*(Any Information Not Available = NA)* *(Entries May Be Typed or Handwritten)* * *If the specimens have been conditioned in any way that makes them different from those usually indicated by this Lot or Identification Number, add a suffix to the Lot or ID Number to indicate this difference, e.g. if Lot RAD890522 was aged 30 days at 60°C it could be written as RAD890522-30D60C*	*(Strain Rate)*	*(Maximum Stress)*	*(Maximum Strain)*	*(Failure Stress)*	*(Failure Strain)*	*(Modulus*
Data Sent To: *(Name and Address of Person Receiving This Information)*			Average						
			S Dev.						

DEF (Unofficial) Revision Date: 26 Apr 91

Report Reference Number: RL00A1	TEST REPORT SHEET Uniaxial Compressive Test (Sample Sheet, Compressive)	Page 1 of 1 Page(s)

TEST SITE INFORMATION

Laboratory: USA Ballistic Research Laboratory
Date: 28 Oct 88
Test Procedure: Uniaxial Compressive Test
NATO Test Procedure Number: 102.01.010
Date Tested: 28 Jul 86
POC: Rob Lieb

TEST CONDITIONS

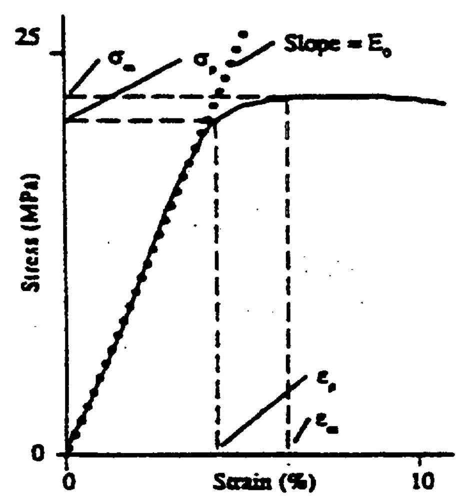
Temperature (°C): 20
Relative Humidity (%): NA
X-Head Speed (mm/sec): 2590
Machine Type: MTS Servohydraulic Tester
Grip Type: NA
Machine Stiffness (kN/mm): 190.

SPECIMEN INFORMATION

Dimensions: (mm) Length (Gage Length): 8.70
Width:
Thickness (Diameter): (8.70)
X-Sectional Area (mm²): 58.0
Form: 7MP
Preparation Method: Diamond Saw - L/D=1
Manufacturing Method: Solventless Extrusion
Source: Radford Army Ammunition Plant
Lot or ID Number: RAD81E001S110
Preconditioning: NA
Conditioning Period: NA
Composition: JA2

Component	Percent
Nitrocellulose	59.5
Nitroglycerin	14.9
DEGDN	24.8
Akardit II	0.70

TYPICAL RESULTS



Test ID	Specimen T (°C)	Specimen S (mm²)	Comments	$\dot{\varepsilon}$ (s^{-1})	σ_m (MPa)	ε_m (%)	$\sigma_{c,p=}$ (MPa)	$\varepsilon_{c,p=}$ (%)	E_0 ~~(MPa)~~ (GPa)
263.01	20	58.0		311	25.0	5.1	23.6	3.5	1.11
263.09	20	58.0		296	23.5	5.4	20.9	4.0	0.76
263.17	20	58.0		292	25.7	5.0	24.9	3.4	1.08
263.25	20	58.0		310	25.6	5.1	23.2	3.6	0.94
263.33	20	58.0		284	24.8	5.2	22.2	3.4	1.05
Data Sent To: Bernard Gondouin, SNPE, 6 Bouchet, 91710 Vert le Petit, France			Average	298	24.9	5.2	23.0	3.6	0.99
			S Dev.	12	0.9	0.2	1.5	0.3	0.14

DEF (Uniaxial) Revision Date 26 Apr 91

Report Reference Number:				TEST REPORT SHEET Uniaxial Compressive Test						Page ____ of ____ Page(s)
Test ID	Specimen T (°C)	 S (mm²)	Comments	$\dot{\varepsilon}$ (s^{-1})	σ_m (MPa)	ε_m (%)	$\sigma_{c,\varepsilon=\varepsilon_l}$ (MPa)	$\varepsilon_{c,\varepsilon=\varepsilon_l}$ (%)	E_0 (MPa) (GPa)	
Data Sent To:			Average							
			S Dev.							

DEF (Uniaxial) Revision Date: 3 Nov 90

RATIFICATION AND IMPLEMENTATION DETAILS
STADE DE RATIFICATION ET DE MISE EN APPLICATION

NATION	NATIONAL RATIFICATION REFERENCE DE LA RATIFICATION NATIONALE	NATIONAL IMPLEMENTING DOCUMENT NATIONAL DE MISE EN APPLICATION	IMPLEMENTATION/MISE EN APPLICATION					
			FORECAST DATE PREVUE			ACTUAL DATE REELLE		
			NAVY MER	ARMY TERRE	AIR	NAVY MER	ARMY TERRE	AIR
BE								
CA	2441-4443 (DACME 2-3) of/du 15.06.95	STANAG 4443						
DA	MA204.69 - S443/MAM3-13554 of/du 27.06.95	STANAG 4443				01.12.97	01.12.97	01.12.97
FR								
GE	BMVg-Fü SIV2 Az 03-51-60 of/du 10.11.95		1.1.98	1.1.98	1.1.98			
GR								
IT								
LU	BO 3520/95 of/du 16.06.95			N.I.			N.I.	
NL	M95014701 of/du 31.07.95	STANAG 4443				1.9.97	31.12.96	31.12.96
NO	MAS-693/95/MST/U3/BØ/ STANAG 4443 of/du 27.07.95					1.1.96	1.1.96	1.1.96
PO	RRN 014/97/DA of/du 05.02.97	STANAG 4443					1.9.97	
SP								
TU	TUDEL-97/260 du/of 20.01.97						1.12.97	
UK	341/8/4443 du/of 09.12.96		1.9.97	1.9.97	1.9.97	1.9.97	1.9.97	1.9.97
US	OUSD(A&T) S&TS/M du/of 22.11.96	STANAG 4443				1.11.96	1.11.96	1.11.96

* See overleaf reservations(*)
Voir au verso réserves (*)

RESERVES/RESERVATIONS